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COLONIAL DEVELOPMENT AND RESEARCH.

MR. MALCOLM MACDONALD'S announcement* on February 20th of an extended policy of Colonial development and of the Government's decision in the matter of the West India Royal Commission has been warmly welcomed in all parts of the Colonial Empire as marking the beginning of a new era in the administrative and financial relations between Great Britain and her colonies which cannot fail to have a profound effect on the future welfare of these territories. The measures now proposed by Government after an examination of Colonial problems which had been begun sometime before the outbreak of the war is an acceptance of an obligation which has long seemed inevitable to those who have been engaged in the scientific investigation of conditions in these dependencies. While much has already been accomplished, there is room for further development of the natural resources of the various territories so as to provide their peoples with improved standards of life.

The conclusion arrived at by Government, after consideration of the effect of such limited resources derived from agriculture as are available in most of the dependencies, in relation to a policy of steady development, is that many colonies cannot finance out of their own resources the research and survey work, the schemes of major capital enterprise, and the expansion of administrative and technical staffs, which are necessary for their full and vigorous development. The old principle that a colony should have only those services which it can afford to maintain out of its own resources is to be abandoned, and in future, assistance will be given not merely for capital expenditure or material development—in the main the objects of the Colonial Development Fund instituted in 1929—but also the money from new sources, now to be provided, is to be made available for the maintenance of important works or services over a substantial period of years.

Briefly, the financial arrangements now proposed for the Colonial Empire as a whole, and the machinery to be instituted for their employment, are as follows:

The Colonial Development Fund, instituted in 1929 and limited to a maximum of £1,000,000 a year, will be replaced by a new vote in the

* Statement of Policy on Colonial Development and Welfare. Cmd. 6175, pp. 8, London, *H.M.S.O.*, 1940.

estimates for assistance to Colonial Governments up to a maximum of £5,000,000 a year for ten years. This assistance will be available not only for schemes involving capital expenditure for colonial development, but also for helping to meet recurrent expenditure on certain services, such as agriculture, education, health and housing. The Government also proposes to make special provision for research. Hitherto, expenditure on various forms of Colonial research has received assistance from the Colonial Development Fund. In future, for this purpose a separate sum will be allocated up to a maximum amount of £500,000 a year.

As regards the manner of allocating expenditure from these funds, the Government will enlist the help of a Colonial Development and Welfare Advisory Committee, which will be composed partly of official and partly of unofficial members. In the province of research, in the past, the authorities have had recourse in dealing with questions of Colonial research to the advice of scientific and technical experts in Great Britain; but they are now anxious to place the system on a wider and more regular basis. It is considered that this object can best be achieved by the establishment of a Colonial Research Advisory Committee. It is not anticipated that the full scale of expenditure will be reached all at once, especially in present conditions; but so far as possible, steps will be taken immediately to give these proposals effect.

In view of the pressing need for a large expenditure on social services and development in the West Indies the Commissioners* have recommended the establishment of a West Indian Welfare Fund to be financed by an annual grant of £1,000,000 from the Imperial Exchequer for a period of 20 years, and of a special organisation to administer this fund under the charge of a Comptroller. This fund is to be used for the general improvement of education, the health services, housing and slum clearance, the creation of labour departments, the provision of social welfare facilities, and land settlement, apart from the cost of purchase of land. The new organisation will be set up within the West Indies but is to be independent of the local governments. Among the Comptroller's chief duties will be the working out of long term programmes of social reform for submission to the Secretary of State, the supervision of grants to West Indian Governments, and the preparation of an annual report for Parliament. Associated with him, will be an Inspector-General of Agriculture; and his staff will include highly qualified technical officers in public health, education, housing, labour problems, and social welfare. The Commissioners also recommend additional preferences on sugar which would cost another £1,000,000 a year.

* West India Royal Commission 1938-39. Recommendations. Cmd. 6174, pp. 30, London, *H.M.S.O.*

In order to implement immediately some of these recommendations the British Government has announced that a sum of £350,000 will be available.

Considerable emphasis is laid by the Commissioners on the vital importance of agriculture in the West Indies. In their own words "Agriculture is the principal source of sustenance and wealth in the West Indies and the standards of life must largely depend on the intensive use of the soil. The outstanding agricultural need . . . . . is more intensive use of the land with increased production of food in order to support a rapidly growing population. The most urgent need is the development of peasant agriculture, but substantial progress among both peasants and estates is dependent upon far-reaching reform of the basic methods now in vogue. The practice of shifting cultivation by peasant farmers must be abandoned and replaced by an organised system of permanent mixed farming; the present policy of those larger proprietors who grow a single crop continuously must be modified by the development of mixed farming in a measure which will vary from place to place with local circumstances. Neither of those reforms can be successfully carried through until new knowledge which is obtainable only by scientific investigations, has been secured". In this connection it is satisfactory to note that it is recommended that all major research and investigation should be centralised under the Imperial College of Tropical Agriculture which, it is proposed, should in addition to its present functions, also serve as the central fundamental research station for the West Indies. The work of Colonial Agricultural Departments will be concentrated on local replications and extension of the central investigations and on advisory and educational work.

In the main, the Commissioners envisage the establishment of a permanent system of agriculture which will not only produce useful crops but also maintain and improve soil fertility. It is certain that hitherto, too little attention has been paid to the problem of how to conserve the natural resources of the land with the result that there is ample evidence in the West Indies, as in many other countries, of soil exhaustion. Our agricultural policy must, therefore, be directed principally against this growing danger. We must aim at the creation of a well balanced system of agriculture which, while eliminating excessive concentration on money crops will involve diversification of crops and stock raising. To this end many lines of enquiry have been suggested by the Royal Commission, and it is on the results of these enquiries and the improvement in our methods of husbandry which will follow from them, that the ultimate solution of the economic problems of the West Indies primarily depends.

The Editor requests that any subscriber who fails to receive *Tropical Agriculture* regularly should communicate with him immediately in order that the matter may be rectified.

THE INFLUENCE OF CLIMATIC FACTORS ON CITRUS SCAB DISEASE.

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I. Introduction.

It has been realised for many years that climatic factors play an important part in determining both the world distribution of the citrus scab disease caused by *Elsinoe citri* and its intensity in a given area. This fungus was introduced to Florida from the Orient about 1885, and was described by Scribner in 1886 (9), since when it has been studied by various workers. Fawcett (3), in 1912, gave a full description of it, isolated the causal fungus, which was at that time known as *Cladosporium citri*, carried out successful inoculation experiments and suggested control measures. Later, in 1921, the same author, after studying the effect of temperature on the growth of certain other fungi, investigated the effect of temperature on the citrus scab fungus (4). He demonstrated the importance of a suitable temperature for infection, and showed that some of the previous inoculation experiments of other workers gave negative results because they were carried out at unsuitable temperatures. Winston (10) followed up this work with a more detailed study in which he showed that not only temperature, but several other factors including humidity and the presence of young tissues on the trees were of importance. Peltier and Frederich (6) working on the same lines, stressed the importance of environmental and climatic factors, and in a later paper (7) attempted to correlate the world distribution of the disease with factors of temperature and rainfall, drawing attention to the absence of the disease in dry areas such as California, Arizona, and other parts of the Mediterranean region.

More recently, the morphology and taxonomy of this and allied species have been exhaustively studied by Jenkins (5), and Bitancourt and Jenkins (2). The perfect stage of the citrus scab fungus was discovered and referred to the Ascomycete genus Elsinoe, while the imperfect Sporotrichum stage was transferred to the genus Sphaceloma. A distinct species of Elsinoe was found in South America on the sweet orange, and was named *Elsinoe australis*. The true sour orange scab, *Elsinoe citri*, which is commonly known as "Citrus Scab", attacks sour oranges, grapefruit, lemons, and other varieties of citrus but not the sweet orange.

The early investigations were mostly carried out in Florida with the common strain of *Elsinoe citri* which attacks both sour oranges and grapefruit under Florida conditions. This strain of the fungus is widely distributed and has attacked sour oranges in Trinidad for many years, but, until recently Trinidad grapefruit has been almost immune from the disease. In 1937 the grapefruit in Trinidad was quite suddenly and severely attacked by this disease, and the fungus concerned was shown to differ somewhat from the common sour orange scab fungus (1). I am indebted to Dr. Jenkins of the United States Department of Agriculture, who has kindly studied isolations made from grapefruit, sour orange and other citrus varieties in Trinidad, for the information that the 'grapefruit strain' differs slightly but constantly in culture from my other isolations. It therefore became essential to find out if the climatic range of this presumed mutant strain differed in any respect from that of the common sour orange scab. Investigations made during the last three years show that although the mutant 'grapefruit strain' has apparently completely overcome the resistance of Trinidad 'Marsh' and other varieties of grapefruit, it differs only slightly in its requirements for infection from the common sour orange strain. But from data collected in the dry season, when low atmospheric humidity often makes infection impossible, it has been inferred that the 'grapefruit strain' requires a slightly longer period with favourable conditions of temperature and humidity than the sour orange strain to establish infections in fruit or leaves.

II. Conditions for Infection.

The conditions enumerated by Fawcett (4) and Winston (10) for the infection of citrus fruits and foliage by the citrus scab fungus are as follows: Firstly, it is obvious that there must be an abundant supply of the spores of the fungus, and secondly, that the susceptible host-plant (the grapefruit or sour orange tree in this case) must have foliage or fruit in a suitable stage for infection. Only young leaves less than half an inch across or fruits less than three-quarters of an inch in diameter can be infected; fruits and leaves which have passed this stage become immune to the disease. Once a leaf or fruit has been infected, the lesion will continue to grow and spread slowly for some time, but even when well established in young tissues, the spread of the fungus when these tissues have passed the infectious stage is negligible. Lesions on old fruits and leaves are always sharply delimited from healthy tissues and have obviously ceased to spread although they still contain viable mycelium and spores. A third condition for infection is moisture, and apparently the relative humidity of the atmosphere must be at or near 100 per cent. saturation to allow infection to take place. Lastly, the temperature at the time of infection must be above 59°F. and below 74°F. Both a saturated atmosphere and a suitable temperature must be maintained for some hours. Observations made on the Trinidad 'grapefruit strain' of the fungus have shown that a period of at least twelve hours is necessary before infection is possible and that for infection

to be certain a longer period of about sixteen hours is necessary. There is reason to believe that in Trinidad the 'sour orange strain' is able to infect sour oranges in a shorter period. It is evident, therefore, that climatic factors, such as rainfall and temperature, will have a marked direct effect on the incidence of the disease. Climatic factors also have an indirect effect by influencing the spore formation and distribution of the fungus, and by promoting or suppressing the growth and production of young leaves and fruit on the trees. For instance, the first heavy rains of the wet season may largely determine the time of flowering of the trees, and this may be of great importance in determining the severity of infection of fruit by the disease for the whole year. It is purely a matter of chance whether or no these four conditions for infection (viable spores, susceptible tissues, high humidity, and correct temperature) are all present for a sufficiently long time on the same day, and therefore outbreaks of the disease tend to be irregular and difficult to foretell. It is, however, always likely that an outbreak of the disease will follow wet weather if young leaves or fruit are present.

III. Effect of Climate on Infection.

In a sub-tropical climate such as Florida, citrus trees make most of their growth and set their fruit in spring and early summer. Temperature and humidity are often favourable to the disease at this time and severe outbreaks of scab result. At other times in the year there is usually but little material on the trees which can be infected, and one or more of the other conditions may be wrong, so that but little infection occurs. In the humid tropics such as Trinidad, a different state of affairs exists. Trees, especially during their first seven or eight years, grow and produce new leaves all the year round, and although the bulk of their fruit is set in May or June at the end of the dry season, many trees carry fruit of all sizes all the year round. There is, therefore, on young trees, except in cases of extreme drought, never a lack of material in a suitable condition for infection which can occur during any month of the year, although of course it is much greater in the wet season from July to December. The spread of the disease right through the year, and the irregularity of flowering are bound to make the control of the disease more difficult.

The spores of the fungus appear to be relatively resistant to adverse conditions. In Florida the fungus 'overwinters' in lesions on old leaves, and it probably can survive the Trinidad dry season in the same way. It has been shown in the laboratory that spores remain viable on dried material for at least four months. Spores probably survive in large numbers detached from the lesions because it was found that a careful 'clean-up' of diseased tissue in the dry season did little to reduce infection when the rains broke.

Table I.

NUMBER OF DAYS ON WHICH INFECTION COULD HAVE OCCURRED, ASSUMING SUSCEPTIBLE MATERIAL TO BE PRESENT ON THE TREES, FROM THERMO-HYGROGRAPH READINGS.

Month.	No Chance.	Improbable.	Probable.	Certain.	Total Days Recorded.	Total Days not recorded.
Estate A.						
1938.						
January ...	28	2	1	0	31	0
February ...	23	5	0	0	28	0
March ...	28	3	0	0	31	0
April ...	16	5	0	0	21*	9
May ...	2	0	1	0	3*	28
June ...	0	0	0	0	0*	30
July ...	19	9	0	3	31	0
August ...	9	14	2	2	27*	4
September ...	11	7	4	3	25*	5
October ...	9	20	0	2	31	0
November ...	2	14	4	10	30	0
December ...	11	14	3	3	31	0
1939.						
January ...	24	6	1	0	31	0
February ...	24	3	0	1	28	0
March ...	16	4	1	2	23*	8
April ...	14	1	0	1	16*	14
May ...	30	1	0	0	31	0
June ...	27	1	2	0	30	0
July ...	22	7	2	0	31	0
August ...	10	14	4	3	31	0
September ...	11	11	4	4	30	0
Totals ...	336	141	29	34	540	98
Estate B.						
1939.						
April ...	29	0	1	0	30	0
May ...	30	1	0	0	31	0
June ...	29	0	1	0	30	0
July ...	26	4	1	0	31	0
August ...	26	4	0	1	31	0
September ...	23	3	3	1	30	0
October ...	25	4	1	1	31	0
November ...	25	3	0	1	29*	1
December ...	13	8	5	1	27*	4
1940.						
January ...	7	5	7	0	19*	12
February ...	14	13	2	0	29	0
March ...	25	6	0	0	31	0
Totals ...	272	51	21	5	349	17

Explanation of Table I.

*Monthly records incomplete. The instruments were often stopped by ants, mud-wasps and other insects, and sometimes had to be removed for repairs and cleaning when there was no spare available.

Conditions assumed to be necessary for infection :—

Temperature below 74°F. Relative humidity at or about 100 per cent. saturation.

No chance : Less than 12 hours.
Improbable : 12-14 hours.
Probable : 14-16 hours.
Certain : 16 hours or more.

Records of relative humidity and temperature have been kept for three years, and continuous records of the time, duration and amount of rainfall have been kept for nearly two years in a large grapefruit orchard which is severely attacked by this disease, and for one year in another orchard which is less severely attacked. Records of considerable interest have been obtained (Table I).

It can be seen from Table II that, generally speaking, the first five months of the year are dry and the following seven months wet. The driest months of the year are February, March and April. Correspondingly, in Table I it can be seen that infection could occur on many more days between June and December than between January and May on both estates. It would also appear that conditions are somewhat less favourable for the disease on Estate B, and this was confirmed by field observations.

The thermo-hygrograph records show that although the temperature falls below 74°F. and the atmosphere becomes saturated with moisture on many nights in the year, the period during which the atmosphere is saturated and the temperature below 74°F. is seldom long enough to permit infection to take place. In the dry season from January to June (the cool season in Trinidad), the dryness of the air is the major controlling factor, while in the wet season from June to December (the hot season), temperature is of greater importance, as, unless there is a fall of rain to cool the air either in the late afternoon or early morning the period of low temperature will be insufficient for infection to take place.

Infection therefore depends to a great extent on the rainfall, and particularly on the time of the rainfall. Table III shows that from January to December, 1938, twenty-three days for 'certain' infection and fifteen for 'probable' infection occurred in Orchard A. Corresponding figures are shown for twelve months in Orchard B. Of these, no 'certain' and only two 'probable' days occurred in the dry season under observation, the remainder occurring from July to December. Although wet days occurred during the dry seasons, little scab developed, but it could always be found, and was undoubtedly sufficient to maintain the supply of spores of the fungus. The relative freedom from scab of growth made during this time is attributed to the fact that purely by chance suitable conditions for infection did not occur when there were large numbers of young leaves on the trees, and also because in the dry season the effects of a shower of rain are very quickly lost. The wet season of 1938 was severe and two or three or more 'certain' days for infection, in addition to some 'probable' and many 'possible' days occurred every month from July to December. Ten 'certain' days occurred in November, and during the second half of November and the first half of December most of the foliage produced was exceedingly heavily infected with the disease. At other times the way in which a day for 'certain' infection has been followed a week or ten days later by an outbreak of the disease has been most noticeable.

As stated above, the time at which rain falls is of importance. An analysis of the thirty-eight days in 1938 on which conditions of temperature and humidity were right for certain or probable infection is given in Table III. It is obvious from the thermo-hygrograph charts that when temperature falls, humidity rises, and *vice versa*, but unless the sky is completely clouded or rain falls in the afternoon between two and five p.m. or in the morning between seven and nine a.m., the necessary long period of saturation and low temperature is not obtained.

IV. Practical Considerations.

The practical importance of these investigations is obvious. In Trinidad, grapefruit trees usually flower in April, May or June, and the weather of the four months April, May, June and July, when the trees carry fruit at a susceptible stage will determine the extent to which the fruit will be damaged by scab. Now the first two of these months are usually dry (Table II), but June is wetter and July may be a very wet month, so

Table II.

MONTHLY RAINFALL FOR PERIOD 1930-1939 AT THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE.

Month.	1930.	1931.	1932.	1933.	1934.	1935.	1936.	1937.	1938.	1939.	Mean Monthly Totals.
January	3.62	1.49	5.26	4.11	1.73	0.74	2.35	6.21	2.22	1.55	2.93
February	1.04	1.12	2.39	0.74	0.83	0.51	1.00	0.81	1.50	2.30	1.22
March	0.61	0.17	6.54	1.23	0.47	0.93	0.45	0.64	3.13	0.97	1.51
April	2.34	1.10	3.52	1.74	0.16	0.28	2.32	2.91	6.07	0.99	2.13
May	2.07	1.31	10.95	5.68	1.49	6.07	6.57	0.47	7.87	3.58	4.61
June	6.97	8.93	11.70	12.42	1.08	3.79	12.79	6.36	4.84	6.07	7.39
July	8.83	15.17	6.93	12.53	3.80	7.75	10.68	4.54	8.66	7.05	8.59
August	4.03	10.90	10.39	11.16	7.30	13.74	10.38	5.66	12.59	8.80	9.49
September	5.71	9.17	5.37	12.33	6.80	13.76	9.67	4.71	7.78	9.09	8.44
October	8.60	11.36	4.10	8.22	11.05	5.56	5.13	6.30	4.77	6.88	7.20
November	2.57	9.26	5.99	7.68	11.75	6.25	8.73	11.38	14.41	3.24	8.13
December	5.88	6.07	9.98	9.51	4.05	5.09	6.88	8.64	9.84	6.47	7.24
Totals	52.27	76.05	83.12	87.37	50.51	64.47	76.95	58.63	83.68	56.99	68.88

fruit which is set early will have a better chance of escaping the disease than late fruit. The conclusion is, however, unavoidable that in most, if not all Trinidad grapefruit areas, days on which infections can develop while the fruit is still susceptible, are bound to occur every year. Spraying is therefore necessary for the control of the disease, but the kind of spray and the number of sprays required will be decided by the climate of the area concerned. Ruehle and Thompson (8) have recently published the results of their detailed spraying trials in Florida. They have found that the low-lying wet estates require more spraying than the drier ones and have worked out spray schedules for different areas. The number and type of sprays required in a given area in Trinidad could probably be forecast from a consideration of adequate meteorological data for the area; for instance, it is evident that Estate A in Table I will require more thorough spraying than Estate B. Spraying experiments are now being carried out by the Department of Agriculture and it is hoped that while two or more copper sprays may be necessary in certain areas such as Estate A, fewer sprays, possibly only one 'clean-up' before the flowers appear, will be adequate in other districts.

Table III.

DAYS IN THE YEAR 1938 ON WHICH INFECTION COULD HAVE OCCURRED.

Date.	Infection.	Hours at Saturation.	Hours below 74°F.	Notes.
Jan. 4	Probable ...	18	15	
June 30	Probable ...	16	15	
July 6	Certain ...	19	18	Rain 1-3 p.m. 6th.
23	Certain ...	18	18	
24	Certain ...	16	16	Rain 11 a.m. 6 p.m. 24th.
Aug. 3	Certain ...	18	16	Rain 1-3 p.m. 3rd.
14	Probable ...	15	16	
23	Certain ...	17	16	Rain 3-4 p.m. 23rd.
26	Probable ...	15	16	
Sept. 6	Certain ...	17	17	Rain 1-3 p.m. 6th.
20	Probable ...	19	15	
22	Probable ...	15	15	
25	Probable ...	16	15	
27	Certain ...	17	18	Rain 2 p.m. 27th.
28	Certain ...	18	17	Rain 2-4 p.m. 28th.
29	Probable ...	15	15	
Oct. 9	Certain ...	20	17	Rain 3-5 p.m. 9th.
21	Certain ...	16	16	Rain 4 p.m. 21st.
Nov. 2	Certain ...	18	17	Rain 2-4 p.m. 2nd.
3	Certain ...	18	16	Rain 2-3 p.m. 3rd.
5	Probable ...	15	15	
6	Certain ...	16	18	
9	Certain ...	17	17	Rain 2-5 p.m. 9th.
10	Certain ...	18	17	Rain 2-6 p.m. 10th.
13	Probable ...	16	15	
14	Certain ...	16	16	
20	Probable ...	15	16	
21	Certain ...	18	18	Rain 2-3 p.m. 21st.
22	Certain ...	18	18	Rain 2-3 p.m. 22nd.
23	Certain ...	20	20	Rain 2-5 p.m. 23rd. 9 a.m. 24th.
25	Probable ...	15	15	
27	Certain ...	18	19	Rain 2 p.m. 27th. 7 a.m. 28th.
Dec. 9	Probable ...	16	15	
10	Probable ...	18	15	
11	Probable ...	16	15	
12	Certain ...	17	18	Rain 4 p.m. 12th.
17	Certain ...	16	16	Rain 2 p.m. 17th. 6, 7, 10 a.m. 18th.
18	Certain ...	24	24	Rain 12 noon, 3 p.m. 18th. 8 a.m. 19th.

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CONTROL OF MOLE CRICKETS.

A bait composed of barium fluosilicate, 5 parts, and water, 25 parts per 100 parts of grain, is as effective as a similar bait containing 5 parts zinc phosphide in controlling the mole cricket (*Gryllotalpa* sp.). The barium fluosilicate bait is not as rapid as the zinc phosphide bait in its lethal action, but both baits have the same ultimate effect. It has the advantage over the phosphide bait in that it is insoluble in water, odourless, easily handled and harmless to the leaves of plants. The barium fluosilicate bait loses its effectiveness in nine to ten days after its preparation. A dose of 100 milligrams barium fluosilicate was lethal to hens weighing approximately 1.5 kilograms, whereas the fatal dose for pigeons was 170 milligrams.—*A. Kassab.* (*Chemical Abstracts*, Vol. XXXIV, No. 3, Col. 846, 1940.)

LIVESTOCK IMPROVEMENT IN THE NORTHERN TERRITORIES OF THE GOLD COAST.

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Introduction.

The Northern Territories is a protectorate in the Gold Coast which varies from savanna to very open plains from South to North. Apart from local food crops, livestock represents the sole money export industry. There is no railway nearer than Kumasi in Ashanti. The Gold Coast and Ashanti are covered with forest, are thickly populated with a comparatively wealthy population thanks to the cacao industry, but save for a few sheep and goats in villages there is no livestock industry. There is a large demand for fresh meat, which is imported on the hoof from French West Africa and the Northern Territories. The supply from French West Africa is decreasing so that more is required from the Northern Territories and it is the policy of Government to improve and increase the livestock industry of the protectorate. To this end, a large anti-rinderpest immunisation campaign was inaugurated ten years ago to prevent the serious losses which inhibited the development of the local cattle trade. Since then, the production of an efficient vaccine has eliminated contagious bovine pleuro-pneumonia, the other serious killing epizootic, so that the control of epizootic disease is satisfactory.

Cattle.

For many years, experimental work has been carried out to improve the local cattle, which are small, hardy, unhumped animals of very fair conformation. They are descended from the ancient Hamitic Longhorn cattle of Africa but most have an infusion of dwarf shorthorn blood while zebu points can be traced in many of the cattle. While the cattle are hardy, they are too small generally for the trade markets where they compare unfavourably with the zebu cattle imported from French West Africa, which are bigger. The local owners are primarily agriculturists and secondarily husbandmen so that the standard of animal husbandry is poor. The usual method of herding is for the village cattle to be tethered at night within the village and sent to graze and water during the day in charge of the boys of the village who are too small for farm work in the fields. In some districts Fulani herdsmen are employed and their cattle are superior to average as the Fulani is a member of a pastoral people whose whole interests and traditions lie in cattle. But generally husbandry is poor and this is emphasised by the neglect to supply suitable bulls for the herds. Under ordinary conditions, good or even mature bulls of any kind are absent from the normal village herd and it is only in the Fulani tended herds that mature bulls are found and even there they are often of an unsuitable type. Thus the cattle of the Northern Territories were small, hardy and very resistant to enzootic disease especially trypanosomiasis, but from an economic viewpoint were very undeveloped. Hence the necessity was to increase size and conformation to produce a good marketable animal while at the same time to retain the general hardiness and resistance to disease. Experiments with British breeds such as Herefords and Shorthorns proved abortive so that for many years experimental work has been carried out with other West African types of cattle and by selection within the existing cattle. The best results with different varieties have been with short, deep-bodied zebu bulls, which when put to the local cow produce what is known as the Sanga type which is intermediate between humped and unhumped cattle but this type breeds fairly true among itself and does not produce markedly segregated characters of zebus, Sangas and West African shorthorns, as the local unhumped cattle are named. Fully half of the Northern Territories cattle are Sangas, particularly in the densely populated Northern areas close to the French frontier. The other benign variety is the N'Dama type which has been specialised in French Guinea among the Fouta Djallon mountains but which occurs sporadically wherever the unhumped cattle are found. This has more genuine Hamitic Longhorn in its make-up than any other type and is particularly resistant to trypanosomiasis and forms a local variety which is of superior conformation and is also more resistant to disease than normal. The N'Dama and its crosses are particularly suited to areas where there is marked tsetse infestation but it is rather small for the Northern part. However, a type of N'Dama-Sanga is being created which will suit the North. Experimental work mainly carried out at the Pong-Tamale farm of the Department of Animal Health had shown what types of cattle could bring about improvement and at the same time preserve the hardiness of the local cattle. Thus a few years ago, the time was ripe for general improvement on a large scale.

Apart from inferior husbandry, the main obstacle to good cattle was the absence of decent bulls in the village herds and any improvement scheme must eliminate this defect. Hence it was decided that the solution must lie initially in the introduction of communally owned bulls to the village herds which could not be disposed of nor castrated by the cattle owners. It so happened that at this time, a change in administrative methods had produced an effective Native Administration so that it was decided that this important economic problem should be solved through the medium of the Native Administrations.

A scheme for the construction of Native Administration cattle farms throughout the protectorate was approved by Government which gave a generous grant of money, which was augmented by the Native Administrations. Within the last few years a couple of dozen such farms have been constructed, stocked with the best local cows procurable and with an improved bull of a type advised and supplied by the Department of Animal Health. The main object of such farms is to produce for the villages improved bulls which remain the property of the various Native Administrations. In addition these farms demonstrate improved husbandry methods with the production of fodder crops, properly made manure, and proper feeding methods. A few such farms have been in existence for some years and have already produced an appreciable number of improved bulls for their districts. The main Government farm at Pong-Tamale is producing approximately one hundred improved bulls per annum, the best of which are supplied to Native Administration farms, the others to village herds. At only one farm has a specific local type of cattle beast been stocked and this exception is due to the fact that in this area only is there a definite local variety. The type is called the White Builsa and is a short, stocky animal of good conformation and white colour with black spots, not unlike the wild British Park cattle. The chiefs and officials of the Native Administrations have co-operated heartily in this improvement scheme, which is as much a triumph for the new method of indirect rule as for its competency as a benign development plan. Thus the bull question is in rapid process of solution and the general husbandry of the village herds is slowly improving. Widespread improvement has begun and the type of cattle beast seen is superior to that of ten years ago. In approved village herds, which have had communal bulls for some years and have been kept under observation, the weight of bullocks has increased from round five cwt. to from six and a half to seven cwt. with a marked betterment in conformation.

A scheme for milk and dairy work is in the experimental stage and promises well.

Pigs.

Pig improvement has advanced considerably and affects not only the pig breeding parts of the Northern Territories but the Colony and Ashanti. The department originally tried Berkshires and Middle Whites, the latter thriving rather better so improvement for years was by means of the introduction of Middle White blood into the native pig, which is a long, rakish black pig. It was found, however, that the cross in some cases was too fat so about ten years ago, Large Whites were introduced and have also done well. Pure-bred and cross pigs are bred at the Pong-Tamale farm and distributed throughout the country on demand to native owners direct, not on communal methods as are the improved cattle. In the Northern Territories pigs are not bred on a large scale save in British Togoland. The improved pigs have done remarkably well wherever they have been sent save when trypanosomiasis has taken toll of them and such places have invariably been in the forest country. It is a curious fact that these white pigs kept under natural conditions and let out to graze during the day in the full rays of the African sun do not suffer from sun scab: this is a fact for which a rational explanation cannot yet be given. To owners in the Colony and Ashanti improved pigs are sold at reasonable prices but in the poorer parts of Togoland pigs are issued free to such persons as construct hygienic sties according to the department's plan. Cassava root is the main artificial food supplied to pigs but care has to be taken that it is well soaked and boiled before feeding in order to avoid prussic acid poisoning, to which pigs are particularly liable. This year the department is constructing a new livestock farm on the coastal plains of the Colony at which it is proposed to install a herd of Large Black pigs, which have not previously been tried out in the Gold Coast but have been very successful in French West Africa, where this breed has been quite the best of all. The pig trade in the Gold Coast is an important one and the present supply is not adequate so there is much room for extension. Prices of fresh meat in the Gold Coast are very high. In Accra which is fairly typical of the Colony towns, a bullock of about 10 cwt. fetches from £12 to £18 while very ordinary hogs fetch from £3. The Gold Coast imports more meat and meat products than any other country in the Empire except the Mother Country itself.

Poultry.

Poultry improvement has also made great strides and has been running successfully for many years. The breeds at present being used are Rhode Island Reds and Black and Brown Leghorns. At Pong-Tamale, there are two poultry branches, one which breeds pure-bred poultry and the other which crosses good types of native hens with Rhode Island and Black Leghorn cocks. It has been found that pure European poultry do well only when placed in charge of breeders whose ideas are ahead of the ordinary native methods so that it is the second method which is in more general use throughout the country and especially in the Northern Territories. Cross-bred poultry do remarkably well and grow to a size comparable with pure-bred birds and lay eggs approaching the same standard. It is an unfortunate fact that it is becoming more difficult to get really hardy birds from British breeders and both avian tuberculosis and fowl paralysis have been introduced by birds bought from reputable home sources; fortunately these conditions have not spread and have now been eliminated at Pong-Tamale. Poultry branches have been incorporated with Native Administration

farms and these produce pure-bred cocks, local native hens, and cross-bred birds for issue throughout the villages. The poultry branch at Pong-Tamale has had considerable effect on the general standard of poultry in the Gold Coast.

The farm has been lucky in having been completely free from epizootic disease until 1937 when a virus disease was introduced, probably by vultures or egrets which are common, and caused the death of several hundred young birds.

TOWN'S REFUSE AS A SOURCE OF SOIL ORGANIC MATTER.*

Although animal and vegetable wastes have been used as manure for untold ages, and their good effect on soil fertility has never been in doubt, chemists and microbiologists would be the first to confess that there are many gaps in our knowledge of their modes of action. To take farmyard manure—still without a rival—we know the value of the plant foods it contains, and its remarkable power, after decomposition, of promoting and conserving the granular structure of the top soil, thereby making it porous to air, absorptive and retentive of moisture. How this physical effect is brought about is still largely a matter of hypothesis; and generally speaking, we know nothing of the sequence of changes that follow the incorporation of farmyard manure with the top soil.

The solution of such questions would help in determining beforehand the possibly beneficial action of many other organic substances that are or might be available to eke out our diminishing supplies of farmyard and stable manures. At the present time, when it is planned to convert millions of acres of inferior grassland into arable, the provision of additional supplies of humus-forming material becomes exceptionally important.

A potential source of supply of organic manure is the refuse of cities and large towns that is now carted away and dumped on to waste land or into the sea. The composition and production of such refuse have, *inter alia*, been investigated by a sub-committee of the Institute of Public Cleansing, and reported upon by H. Edridge (1937). Samples of the refuse collected from 485,894 houses, with 2.082 million people, contained an average of 13.23 per cent. of vegetable and putrescible matter, corresponding to more than one million tons of such matter contained in the estimated total of 8.3 million tons for the entire annual output of the United Kingdom. The percentage of organic matter in the refuse varied considerably with the class of dwelling; that from artisans was 9.96, from the middle class 15.33, and from the 'better' class 16.62. Paper averaged 14.29 per cent., and rags 1.89 per cent.

The question arises, therefore, whether such refuse can be used as an organic manure, either directly or after processing. As criteria of suitability the main considerations are: contents of nitrogen, cellulose and lignin, and rate of decomposition in the soil. Although little work has been done in these directions, a few practical men have been forestalling scientific inquiry. The Corporation of St. Albans, Herts, is producing material that is reported to have given good results on neighbouring farm land, and the Royal Borough of Kensington is disposing of all its refuse to a private company that is converting it into an organic manure in a plant designed to treat 250 tons a day. A similar plant is to be in operation at Harrow early this year. The process is simple: grosser solids like metal containers, glass, and paper are picked out by hand on moving belts; the material is crushed, sprayed with a culture of nitrogen-fixing bacteria, and then allowed to ferment, aerobically and anaerobically, for 16 days in large chambers. The product has little odour, and is a coarse brown powder containing about 30 per cent. of organic matter (with about 1 per cent. of nitrogen), 40 per cent. of inorganic solids, and 30 per cent. of moisture.

Large-scaled replicated experiments to determine its manurial value were undertaken by the Rothamsted Experimental Station on a wide variety of soils at Rothamsted on kale, Woburn on sugar-beet, Tunstall (Suffolk) and Siddlesham (Sussex) on potatoes, and at High Halstow (Kent) on mangolds. The treated town's refuse (termed 'Hyganic') was compared with farmyard manure, rape-dust, and sulphate of ammonia in single and double doses. The chief interest lies in the comparison with farmyard manure at Rothamsted where, on an equal nitrogen basis, 'Hyganic' proved superior three times out of four; and at Woburn where, although the differences in terms of sugar per acre were not statistically significant, there was an advantage of 3 cwt. per acre of sugar in favour of 'Hyganic' when double dressings (1.6 cwt. nitrogen per acre) were applied. The value of the nitrogen in the manure was found to be nearly equal to one-half that in sulphate of ammonia.

The results apply to the year of application only (residual effects were not examined), but they show that the organic matter in the town's refuse decomposes quickly, rendering the contained nitrogen readily available. The relatively rapid decomposition in the soil may well be associated with the beneficial effect on soil texture, which has been observed by market-gardeners and others, thus supporting Geltzer's generalization that the rate of decomposition of organic matter in a soil is directly related to the stability of the larger soil-aggregates that determine a good tilth.—(Article by E. H. Tripp in *Nature*, Vol. CXLV, No. 3663, p. 56, 1940.)

* See also *Tropical Agriculture*, XVI, No. 9, p. 206.

DISTRIBUTION OF FUNGOUS DISEASES OF CROP PLANTS IN THE CARIBBEAN REGION.

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INTRODUCTION.

This list has been compiled with the help of the mycologists, agricultural officers and other scientific workers in the countries concerned. Without their co-operation it could not have been attempted, and the author wishes to put on record his sincere thanks for their help.

It is a summary of the replies received to a detailed questionnaire which was sent out in May, 1939. It is by no means complete and merely represents an attempt at determining the distribution of the more important diseases of the major crops of the Greater and Lesser Antilles for plant quarantine purposes.

No notice has been taken of ' doubtful ' records. In cases of doubt and when information is lacking the country is simply omitted from the list.

It is probable that many mistakes have been made, but it is felt that the publication of the list at this stage is justified, and the co-operation of scientific workers in the countries concerned is asked in correcting the mistakes and in making additions to the list. Definite records of the presence of diseases are probably of more value than records of their absence, as, in the smaller islands especially, the diseases of many crops have never been fully investigated, and unless they constitute a serious menace to the crops concerned, their presence is not recognised.

In the more northerly islands such as Bermuda, and in countries with high mountains, certain temperate or sub-tropical fruits and vegetables, such as grapes and potatoes (*Solanum tuberosum*), can be raised. Many of the common diseases of these crops have been recorded but are not included in this list.

ABBREVIATIONS.

Ant. & B.	Antigua & Barbuda.
B'dos	Barbados.
Berm.	Bermuda.
B.G.	British Guiana.
Br. Hon.	British Honduras.
C'cou	Carriacou (Grenadines).
Cuba	Cuba.
Dom.	Dominica.
Gren.	Grenada.
Guad.	Guadeloupe.
Haiti	Haiti.
Jam.	Jamaica.
Mart.	Martinique.
Mont.	Montserrat.
P. Rico	Puerto Rico.
St. K. & N.	St. Kitts & Nevis.
St. L.	St. Lucia.
St. V.	St. Vincent.
T. & T.	Trinidad & Tobago.

SUGAR CANE.

Bacterium vascularum (Gumming Disease, Cobbs Disease).
In : Ant. & B., B'dos, Br. Hon., Guad., Mart., St. K. & N., St. L., St. V.
Not in : B.G., C'cou, Cuba, Gren., Jam., Mont., T. & T.

Mosaic Disease (Virus).
In : B'dos, Cuba, Haiti, Jam., Mart., P. Rico, St. K. & N., T. & T.
Not in : B.G., Br. Hon., C'cou, Dom., Gren., Mont., St. L.

Leptosphaeria Sacchari (Ring Spot).
In : B'dos, B.G., Br. Hon., Cuba, Haiti, Jam., Mart., P. Rico, St. K. & N., T. & T.
Not in : C'cou, Dom., Gren.

Helminthosporium Sacchari (Eye Spot).
In : B'dos, Br. Hon., Cuba, Jam., Mart., P. Rico, T. & T.
Not in : B.G., C'cou, Gren.

Marasmius Sacchari (Root Disease).
In : Ant. & B., B'dos, B.G., Cuba, Gren., Guad., Haiti, Jam., Mart., P. Rico, St. K. & N., St. L., St. V., T. & T.
Not in : Br. Hon., C'cou, Dom.

Notes :
1. Pokkah Boeng (*Fusarium* sp.) and *Bacterium rubrilineans* occur in Cuba.
2. Many other relatively unimportant diseases of sugar cane have a wide distribution in the West Indies.

RICE.

Note :
Only cultivated extensively in British Guiana and Trinidad.

Tilletia horrida (Bunt).
In : B.G., Br. Hon., T. & T.
Not in : Cuba, Gren.

Sclerotium Oryzae (Sclerotial Disease).
In : B.G., T. & T.
Not in : Br. Hon., Gren.

Fusarium moniliforme ('Bakanae' or 'Man Rice').
In : B.G.
Not in : Br. Hon., Gren., T. & T.

MAIZE.

Ustilago Zeae (Smut).
In : Ant. & B., Berm., B.G., C'cou, Cuba, Gren., Guad., Haiti, Jam., Mart., Mont., St. K. & N., St. L., St. V., T. & T.
Not in : Br. Hon., Dom.

Leaf Stripe Disease (Virus).
In : B'dos, C'cou, Cuba, Haiti, Mart., P. Rico, St. L., T. & T.
Not in : Berm., B. G., Gren.

Helminthosporium turcicum (Leaf Blight).
In : B'dos, Br. Hon., Cuba, Jam., P. Rico, T. & T.
Not in : Berm., B.G., C'cou, Gren., St. L.

SORGHUM.

Leaf Stripe Disease (Virus).
In : Jam., St. K. & N.
Not in : Berm., B.G., C'cou, Gren.

Notes :
1. The common rusts of maize and sorghum are widely distributed.
2. *Sorosporium reilianum* (Head Smut) of maize and *Sphacelotheca Sorghi* (Covered Smut) of sorghum are recorded from Jamaica, and *Sphacelotheca cruenta* (Loose Smut) of sorghum from Cuba. Any further information about the distribution of these smuts would be appreciated.

FODDER GRASSES.

GUATEMALA GRASS (*Tripsacum laxum*).

Puccinia polysora (Rust).
In : Br. Hon., Cuba, Jam., Mart., St. L., T. & T.
Not in : B.G., C'cou, Dom., Gren.

GUINEA GRASS (*Panicum maximum*).

Cercospora fusimaculans (Leaf Spot).
In : Jam., T. & T.
Not in : C'cou, Gren.

ELEPHANT GRASS (*Pennisetum purpureum*).

Helminthosporium sp. (Leaf Spot).
In : St. K. & N., St. V., T. & T.
Not in : B.G., Br. Hon., C'cou, Cuba, Dom., Gren.

PARA GRASS (*Brachiaria mutica*).

Puccinia panicicola (Rust).
In : Br. Hon., Jam., T. & T.
Not in : Berm., B.G., C'cou, Cuba, Dom., Gren.

COCONUTS.

Bronze Leaf Wilt (Physiological).
In : B.G., C'cou, Haiti, Jam., T. & T.
Not in : St. L., St. V.

Phytophthora palmivora, &c. (Bud Rot).
In : B'dos, B.G., Cuba, Gren., Haiti, Jam., P. Rico, St. K. & N., St. L., T. & T.
Not in : C'cou, Dom., Mont.

Little Leaf Disease (Physiological).
In : B.G., C'cou, Gren., Haiti, Jam., St. L., St. V., T. & T.
Not in : Br. Hon., St. K. & N.

Aphelenchus cocophilus (Red Ring, Eelworm Disease).
In : Br. Hon., Gren., St. V., T. & T.
Not in : B.G., C'cou, Cuba, Dom., Haiti, Jam., Mont., St. K. & N. St. L.

Thielaviopsis paradoxa (Stem Bleeding Disease).
In : Br. Hon., Cuba, Gren., Jam., P. Rico, St. L., St. V., T. & T.
Not in : B.G., C'cou, Dom., Mont., St. K. & N.

Note:
Many minor diseases of coconuts occur.

CACAO.

Marasmius perniciosus (Witches' Broom Disease).
In: B.G., Trinidad (Tobago first recorded 1939).
Not in: Br. Hon., C'cou, Cuba, Dom., Gren., Jam., Mart., Mont., St. K. & N., St. L., St. V.

Phytophthora palmivora (Black Pod & Canker).
In: B.G., C'cou, Cuba, Dom., Gren., Guad., Haiti, Jam., Mart., St. L., St. V., T. & T.

Botryodiplodia Theobromae (Die-back & Brown Pod).
In: B.G., Cuba, Dom., Gren., Haiti, Mart., St. L., T. & T.
Not in: C'cou.

Colletotrichum spp. (C. luxificum, C. Cradwickii, C. gloeosporioides, &c.) (Anthracnose).
In: Cuba, Guad., Haiti, Jam., Mart., T. & T.
Not in: B. G., C'cou, Dom., Gren.

Corticium & Marasmius spp. (Threadblights).
In: B.G., Gren., Guad., Mart., P. Rico, T. & T.
Not in: C'cou, Cuba, Mont.

Rosellinia pepo & R. bunodes (Root Diseases).
In: Dom., Gren., Guad., Haiti, Jam., Mart., St. L., T. & T.
Not in: B.G., C'cou, Cuba.

Cephaleuros parasitica (Red Rust, Algal Disease).
In: Gren., Guad., Jam., Mart., St. L., St. V., T. & T.
Not in: Br. Hon., C'cou, Dom.

Corticium salmonicolor (Pink Disease).
In: B.G., Br. Hon., Mart., St. L., T. & T.
Not in: C'cou, Cuba, Dom., Gren.

COFFEE.

Rosellinia pepo (Root Disease).
In: Br. Hon., Dom., Gren., Guad., Haiti, Jam., Mart., T. & T.
Not in: B.G.

Omphalia flavida (Viruela).
In: B.G., Cuba, Guad., Haiti, Jam., Mart., P. Rico, T. & T.
Not in: Dom., Gren.

Corticium salmonicolor (Pink Disease).
In: Br. Hon., Mart.
Not in: B.G., Cuba, Dom., Gren.

Sclerotium coffeicolum.
In: B.G., Guad., Mart., T. & T.
Not in: Cuba, Dom., Gren.

Corticium & Marasmius spp. (Threadblights).
In: Cuba, Jam., P. Rico, T. & T.
Not in: B.G., Dom., Gren.

Cephaleuros parasitica (Red Rust, Algal Disease).
In: Guad., Haiti, Mart., T. & T.
Not in: B.G., Br. Hon., Dom., Gren.

Note:
No attempt has been made to separate the diseases of the three species *C. Arabica*, *C. robusta* and *C. Liberica*. One or more species is often highly resistant or immune to certain diseases.

CITRUS.

GRAPEFRUIT.

Elsinoe Citri, Sphaceloma Fawcetti (Scab).
In: Berm., Br. Hon., Cuba, Haiti, Jam., P. Rico, T. & T.
Not in: B.G., C'cou, Dom., Gren., Mont., St. K. & N.

Corticium salmonicolor (Pink Disease).
In: B.G., Br. Hon., Mart., P. Rico, T. & T.
Not in: Berm., C'cou, Cuba, Dom., Gren.

Diaporthe (Phomopsis) Citri (Melanose).
In: Br. Hon., C'cou, Cuba, Gren., Jam., T. & T.
Not in: B. G., Mart.

Phytophthora parasitica or **P. citrophthora** (Gummosis, Mal de Gomma).
In: Berm., Br. Hon., Cuba, Dom., Haiti, Jam., Mart., Mont., St. L., T. & T.
Not in: B.G., C'cou, Gren., St. K. & N.

SWEET ORANGE.

Elsinoe Citri (or ? **Elsinoe australis**) (Scab).
In: Br. Hon., Haiti, Jam., Mart., Mont., P. Rico, St. V.
Not in: Berm., B.G., C'cou, Cuba, Dom., Gren., St. K. & N., T. & T.

Diaporthe (Phomopsis) Citri (Melanose).
In: Br. Hon., C'cou, Cuba, Jam., P. Rico.
Not in: Berm., B.G., Dom., Gren., Mart., T. & T.

Phytophthora parasitica or **P. citrophthora** (Gummosis, Mal de Gomma).
In: Berm., Br. Hon., Cuba, Dom., Haiti, Jam., Mart., Mont., St. L., T. & T.
Not in: B.G., C'cou, Gren., St. K. & N.

SOUR ORANGE.

Elsinoe Citri, Sphaceloma Fawcetti (Scab).
In: Berm., B.G., Br. Hon., Cuba, Dom., Jam., Mart., Mont., P. Rico, St. L., St. V., T. & T.
Not in: C'cou, Gren., St. K. & N.

Phytophthora parasitica or **P. citrophthora** (Gummosis, Mal de Gomma).
In: Br. Hon., Dom., T. & T.
Not in: Berm., B.G., C'cou, Cuba, Gren., St. K. & N.

LIME.

Sphaerostilbe repens (Red Root Disease).
In: B.G., Dom., Jam., Mont., St. L., T. & T.
Not in: Ant. & B., Berm., Br. Hon., C'cou, Cuba, Gren., St. K. & N.

Gloeosporium limetticolum (Wither-tip).
In: Ant. & B., Berm., B.G., Br. Hon., Cuba, Dom., Gren., Jam., Mart., Mont., St. K. & N., St. L., T. & T.
Not in: C'cou.

Note:
Botryodiplodia Theobromae or *Diplodia Natalensis* is probably a common cause of stem-end rot in the West Indies. *B. Theobromae* is an important cause of citrus wastage in Trinidad.

LEMON.

Elsinoe Citri, Sphaceloma Fawcetti (Scab).
In : Br. Hon., Dom., P. Rico, T. & T.
Not in : Berm., B.G., Cuba, Gren.

MANGO.

Colletotrichum gloeosporioides (Blossom Blight).
In : Ant. & B., B'dos, Br. Hon., Cuba, Dom., Gren., Guad., Haiti, Jam., Mart., P. Rico, St. L., St. V., T. & T.
Not in : C'cou.

Colletotrichum gloeosporioides (Anthracnose).
In : Ant. & B., B'dos, B.G., Br. Hon., Cuba, Gren., Guad., Haiti, Jam., Mart., Mont., P. Rico, St. K. & N., St. L., St. V., T. & T.
Not in : C'cou.

AVOCADO.

Sphaceloma Perseae (Scab).
In : Cuba, Guad., Jam., St. V.
Not in : Berm., B.G., C'cou, Gren.

Colletotrichum gloeosporioides (Anthracnose).
In : Berm., C'cou, Cuba, Gren., Jam., Mart., Mont., St. K. & N., T. & T.

PAPAW.

Mosaic Disease (? Virus).
In : B'dos, B.G., Cuba, Haiti, Jam., P. Rico, St. K. & N., T. & T.
Not in : Berm., C'cou, Gren.

Colletotrichum gloeosporioides (Anthracnose).
In : Br. Hon., C'cou, Cuba, Gren., Guad., Haiti, Mart., Mont., P. Rico, St. K. & N., T. & T.
Not in : Berm., B.G., Dom.

NUTMEG.

Rosellinia pepo (Root Disease).
In : Br. Hon., Dom., Gren., Mart., St. L.
Not in : B.G.

Corticium sp. (Threadblight).
In : Gren., Mart., T. & T.
Not in : B.G., Dom.

TONKA BEAN.

Marasmius sp. (Threadblight).
In : T. & T.
Not in : B.G., Br. Hon., Dom., Gren.

PIMENTO.

Puccinia Psidii (Rust).
In : Haiti, Jam.
Not in : Berm., B.G., Dom., Gren., T. & T.

BANANA.

Cercospora Musae (Sigatoka Disease, Leaf Spot).
In : B.G., Br. Hon., Cuba, Dom., Gren., Guad., Haiti, Jam., Mart., P. Rico, St. V., T. & T.
Not in : B'dos, Berm., C'cou, Mont., St. K. & N., St. L.

BANANA.—(*Contd.*)

Cordana Musae (Leaf Spot).
In : B.G., Br. Hon., Cuba, Gren., Guad., Haiti, Jam., Mart., P. Rico, T. & T.
Not in : C'cou.

Fusarium Cubense (Panama Disease).
In : B'dos, B.G., Br. Hon., Cuba, Dom., Gren., Haiti, Jam., P. Rico, St. L., St. V., T. & T.
Not in : Berm., C'cou, St. K. & N.

Bacterium Solanacearum (Moko Disease).
In : B.G., Dom., Gren., Guad., Haiti, T. & T.
Not in : Berm., C'cou, St. L.

Note :
Many minor diseases and most of the common fruit rots occur in all banana growing countries.

PINEAPPLE.

Minor diseases occur in :
Ant. & B., B.G., C'cou, Cuba, Gren., Guad., Haiti, Jam., Mart., Mont., P. Rico, St. K. & N.

TOBACCO.

Bacterium Solanacearum (Wilt).
In : Br. Hon., Cuba, Dom., Guad., Haiti, P. Rico.
Not in : B.G., C'cou, T. & T.

Fusarium vasinfectum (Wilt).
In : Br. Hon., Cuba, Dom., Guad., Haiti.
Not in : B.G., C'cou, T. & T.

Phytophthora Nicotianae (Foot Rot).
In : Cuba, Jam., P. Rico, T. & T.
Not in : B.G., Br. Hon., C'cou, Dom.

Cercospora Nicotianae (Frog-eye Spot).
In : B.G., Br. Hon., Cuba, Gren., Jam., P. Rico, T. & T.
Not in : C'cou, Dom.

Erysiphe Cichoracearum (Mildew).
In : Br. Hon., Haiti.
Not in : B.G., C'cou, Dom., T. & T.

Peronospora Hyocyami (Downy Mildew).
In : Br. Hon., Haiti, Jam.
Not in : B.G., C'cou, T. & T.

Mosaic Disease (Virus).
In : B.G., Cuba, Guad., Haiti, Jam., P. Rico, St. K. & N., T. & T.
Not in : C'cou, Dom.

COTTON.

Rhizoctonia Solani (Black Shank).
In : T. & T.
Not in : Ant. & B., Berm., Br. Hon., C'cou, Dom.

Fusarium vasinfectum (Wilt).
In : Guad., Mont., St. K. & N., St. V.
Not in : Ant. & B., Berm., Br. Hon., Dom., T. & T.

Rhizoctonia bataticola (Root Rot).
In : St. K. & N., T. & T.
Not in ; Ant. & B., Berm., Br. Hon., Cuba, Dom.

COTTON.—(*Contd.*)

Bacterium Malvacearum (Angular Leaf Spot, Black Arm).
In : B'dos, C'cou, Cuba, Gren., Guad., Haiti, Mont., St. K. & N., St. V., T. & T.
Not in : Ant. & B., Berm., Dom.

Glomerella (Colletotrichum) Gossypii (Anthracnose).
In : B'dos, B.G., C'cou, Guad., Haiti, Mont., St. K. & N., T. & T.
Not in : Ant. & B., Berm., Br. Hon., Dom., Gren.

Nematospora spp., &c. (Internal Boll Disease).
In : B.G., Br. Hon., C'cou, Cuba, Mont., St. K. & N., St. V., T. & T.
Not in : Berm., Dom.

Phytophthora parasitica (Soft Rot of Bolls).
In : C'cou, Haiti, Mont., P. Rico, St. K. & N., St. V., T. & T.
Not in : Berm., Dom.

Kuehneola Gossypii (Rust).
In : Berm., B.G., Cuba, Haiti, P. Rico, St. K. & N., St. V., T. & T.
Not in : Ant. & B., Dom.

Ovulariopsis Gossypii (Leaf Mildew).
In : C'cou, Gren., Mont., St. K. & N.
Not in : Ant. & B., Berm., Cuba, Dom.

Ramularia areola (Areolate Mildew).
In : Cuba, P. Rico, T. & T.
Not in : Ant. & B., Berm., C'cou, Dom.

TOMATO.

Fusarium vasinfectum (Wilt).
In : Berm., B.G., C'cou, Cuba, Dom., Gren., Guad., Haiti, Mart., Mont., St. K. & N., T. & T.

Cladosporium fulvum (Leaf Mould).
In : Ant. & B., B'dos, Berm., B.G., Cuba, Dom., Jam., Mart., P. Rico, St. K. & N., St. L., T. & T.
Not in : C'cou, Gren.

Septoria Lycopersici (Leaf Spot).
In : Berm., Cuba, Haiti, Jam., P. Rico, St. K. & N., St. V., T. & T.
Not in : B.G., C'cou, Gren., Mont.

TOMATO.—(*Contd.*)

Blossom-end Rot (Physiological).
In : Ant. & B., B'dos, Berm., B.G., Br. Hon., C'cou, Cuba, Dom., Gren., Guad., Jam., Mart., Mont., P. Rico, St. K. & N., St. L. St. V., T. & T.

Phytophthora parasitica (Fruit Rot, Buck-eye Rot).
In : Berm., Cuba, Mont., P. Rico, T. & T.
Not in : Ant. & B., B.G., Br. Hon., C'cou, Dom., Gren.

Phoma destructiva (Fruit Rot).
In : Berm., Br. Hon., C'cou, Cuba, Dom., Gren., Haiti, Jam., Mont., P. Rico, St. K. & N., T. & T.
Not in : B.G.

Phytophthora infestans.
In : Berm., Jam., Mont.
Not in : T. & T.

SWEET POTATO.

Albugo Ipomoeae-panduranae (White Rust).
In : B'dos, Berm., B.G., Br. Hon., Cuba, Haiti, Jam., Mart., P. Rico, T. & T.
Not in : C'cou, Dom., Gren.

YAM.

Cercospora batatae.
In : Cuba, Haiti, Jam., Mart., P. Rico, T. & T.
Not in : Ant. & B., C'cou, Dom., Gren.

BEANS.

Mosaic Disease (Virus).
In : B'dos, Berm., B.G., Cuba, Haiti, Jam., Mont., P. Rico, St. K. & N., T. & T.
Not in : C'cou, Gren.

CUCURBITS.

Erysiphe Cichoracearum (Mildew).
In : B'dos, Berm., Br. Hon., Cuba, Dom., Haiti, Jam., Mart., St. V., T. & T.
Not in : B.G., C'cou, Gren.

Pseudoperonospora cubensis (Downy Mildew).
In : B'dos, Berm., Cuba, Haiti, Jam., P. Rico, St. L., T. & T.
Not in : C'cou, Dom., Gren.

ORANGE WASTE AS FERTILISER.

In a paper from workers at the Agricultural Laboratory, Anaheim, California it is suggested that a vast quantity of orange waste which is disposed of unprofitably each year, should be returned to the land as fertilizer. It is demonstrated that citrus waste is of equal value in all respects to a standard product known as dairy manure except during spring when an additional 50 lb. of actual nitrogen per acre should be spread over the waste. Pulp and peel have similar reactions on the soil. The heavy use of orange waste on very sandy soils has increased their retentiveness of water by 20-30 per cent. Application should be at the rate of 300-500 lb. per tree. To prepare the waste for the soil it is best to shred it by a mechanical shredder, this reduces its volume by 49 per cent. and the pulp absorbs 95 per cent. of the juice. The mechanical details involved in the use of this equipment, known as the Sander-Backs shredder, are being worked out by the Mutual Orange Association, Placentia, Calif.—(*Horticultural Abstracts*, Vol. IX, No. 4, p. 351.)

SOIL AND VEGETATION.*

A NATURAL plant cover is in many ways an expression of the effective influences of site, soil and climate. For this reason the inspection of vegetation has sometimes been regarded as a superior substitute for the study of soils, especially in reconnoitring the agricultural potentialities of undeveloped country. The underlying supposition is that all soil properties that are really significant in the given circumstances will receive expression through the plants, and that any remaining properties can be safely neglected. This supposition is, however, a valid one only in simple cases, which are rather rare ; and as the basis of a practical or "commonsense" method of assay it has repeatedly led to mistakes in land utilization, particularly in the exploitation of tropical forests and of natural grasslands. If used uncritically it is liable to fail, firstly because botanical science is not yet equipped to apply it, and secondly because of an imperfect appreciation of the nature of the relationship between plants and soil.

To be fair to the botanist it should be said that soil scientists have still a great way to go to meet them in the neglected field, which is that of the classification of plants by their nutritional requirements and tolerances—one might say, by their standards of living. The prospective user of land is not directly interested in the families, genera and species of the plants that are reported as growing on the soil in the natural state. He desires to hear, rather, whether these plants are such as have a reputation as luxurious feeders or on the contrary are known to be able to make do on little. He would like to be warned if they are plants with special requirements or able to stand this or that extreme soil condition. If the botanical information could be cast into this form it would enable at least an approximate idea of the soil's true character to be obtained before development began.

Some vegetation types as ordinarily described do, of course, convey this information partially. Swampiness and extreme droughtiness are usually sufficiently indicated. In better known floras which have been studied in conjunction with soil conditions, a certain number of "indicator plants" may be recognized as generally associated with particular soil characters, such as high acidity, liminess or salinity. Such plants are a small minority, however, especially in tropical floras, and the indications they can give in our present state of knowledge are extremely limited. Yet all plants must indicate something if they are in any way an "expression" of soil conditions ; and what most of them could tell about the soil is quite insufficiently known. In the animal world, a prevalence of sparrows or of elephants tells of an abundance of the food they like and a rarity of conditions they cannot tolerate. In the world of higher plants, the corresponding inferences are presumably there to be drawn, but the necessary physiological knowledge and knowledge of what are the significant soil factors (if any), are lacking for most wild species, even for the dominants and commonest associates of very widespread vegetation types.

That is one very serious weakness in the method of "land reconnaisance through vegetation". The other is due to the fact that, however faithfully a natural vegetation may reflect the natural conditions that have promoted it, we frequently propose to change or entirely remove that vegetation for the purposes of our own use of the land, and we shall thereby change the conditions, perhaps fundamentally. A soil and its plant-cover have identities that are not separable, but are interlocking. What have been regarded as forest soils, or prairie soils, or other soil-types described in terms of their natural vegetation, cease to be such within a short period after the trees have been felled or the sod ploughed. From that point of sharp discontinuity the soils begin a new career in association with the new vegetation formed by the crop and its weeds, or without any such association in-so-far as the ground is kept clean-tilled. The soil properties that were significant to the natural plant-cover, and receive expression in it, are not usually those that will be of most significance to the crop that has replaced it. The crop plants will have a more urgent seasonal demand for nutrients, yet may well be less efficient in stopping losses due to leaching and erosion. They may have a different range of tolerances. The success of a natural vegetation upon a given soil, even to the point of luxuriance, is not in itself evidence that the soil can successfully support man through the different kind of vegetation that he will establish.

To overlook these difficulties is like accepting a testimonial, written for a butcher, as recommendation for the post of baker or candlestick-maker. The error has, however, been common enough in the history of the development of virgin lands, and examples of a very recent date were demonstrated to me in Trinidad and British Guiana. Two of these involved the attempted conversion of forest lands to permanent agricultural use, and one was an undertaking purely in forestry.

Some of the natural forests of Trinidad have timber that is of little value except for conversion into charcoal, for which there is a large local demand as fuel for domestic cooking. It has therefore been sought to replace such forest growth either by permanent peasant cultivations or by more valuable stands of timber to be planted after clear felling, the cost of clearing being covered in either case by the value of the charcoal.

* Article by G. Milne, M.Sc., F.I.C. reprinted from *The East African Agric. Jr.*, Vol. V, No. 4, pp. 294-298. 1940. (*This article contains the substance of one of the chapters of a report recently rendered by Mr. Milne on a study journey he made in* 1938 (*with the assistance of the Carnegie Corporation of New York*) *to parts of the West Indies and the United States.*)—Ed. "E. African Ag. Jr.".

The soil-types concerned are sandy, and the rainfall is high, but it was supposed that the luxuriance of the mixed forest, worthless though the forest was as timber, indicated that a high fertility had accumulated. On the tract cleared for permanent agricultural occupation, the results have, however, been very disappointing. After only a few years cropping, the productivity of the soil has dropped, until a subsistence is no longer afforded to the peasant cultivators. When I was shown the area, many of the holdings were already abandoned. The settlers were of an industrious stock originally brought in as indentured labour from India, and neither lack of skill on their part, nor soil erosion in any form, could fairly be blamed ; the original estimate of the soil's productive capacity under agricultural crops had been at fault, having been based on inference from the aspect of the vegetation. On the reafforestation project, also on a sandy soil but in a forest reserve, the cultivators had been brought in as temporary occupants only, as agents of cheap clearing who would pay themselves for their labour through the charcoal they made, plus one season's crops, in lieu of wages. After they had gone, the Forest Department had experienced the greatest difficulty in establishing the desired stands of valuable trees (though these were of indigenous species) on the land that had been cleared and once cropped in this manner. In showing me over the ground, the Conservator of Forests expressed the opinion very strongly that giving over the land to the cultivator for even one year had been an expensive mistake ; the replanting operations had been handicapped thereby to the point of defeat. The only hope of replacing natural forest by commercial forest lay in preserving the continuity of true forest conditions through the transition, as far as possible. The forest soil, in other words, ought to have been maintained as an entity, without changing it first into something else by alien processes of tillage and exposure.

Both these Trinidad soils had had a fertility quite sufficient to support a strong growth of natural mixed forest, or to grow satisfactory stands of commercial timbers instead, but they possessed this fertility only so long as the reaction of forest vegetation upon soil properties was maintained without interruption. It was not a fertility expressible through field crops, nor persisting through an agricultural phase of utilization to be manifested again through trees. The clearing, burning and tillage necessary for the planting of field crops had dismembered the soil as a working system, and the "scrap" that was left did not provide the makings of an agricultural soil. Not even a good forest soil could be rebuilt from it, for there had been a loss of essential parts and the mechanisms of a year or two before could not be restored to working order.

The example I was shown in British Guiana repeated, with even greater emphasis, the same warning. Sandy country carrying rain forest had been crossed by a new road leading from Bartica (at the junction of the Essequibo and Mazaruni Rivers) to mining settlements in the far interior. Peasant smallholders were to be established in a string of clearings to be made along this road. After making a soil reconnaisance, the agricultural chemist reported adversely on the prospects of any form of agricultural settlement on this land, and advised that the best use to which the soil could be put would be to continue to support its potentially valuable cover of *wallaba* timber (*Eperua falcata* Aubl.). This was in 1934. He was, however, overruled by Government, and the clearings were made and the settlement scheme proceeded with ; the forest itself was evidence of what the land could grow. When I was shown the area in April, 1938, the cultivations were derelict and the settlers mostly gone. They had planted maize, cassava and pumpkins for from two to three years, and had thereafter been unable to make a living. On the abandoned clearings, the only forest tree of value that showed signs of natural regeneration was the tonka-bean tree, *Dipteryx odorata* Willd., a single large specimen of which had been left standing and had shed seed. The prospects of re-establishing *wallaba* forest were, I was given to understand, small. In this case also, a lay estimate of fertility had been based on the stature and luxuriance of the virgin forest, and though the estimate was valid enough for that particular forest crop on its own unaltered soil, it proved to be at fault for the crops of cultivation.

The changes that soils may suffer by loss of a mutual relationship with a native vegetation are seen also in what may be called the "exploitative" forms of utilization of grasslands, or of grass-with-shrub lands such as the sage-bush types of the dry western United States. The over-grazing of pasturage, and the conversion of grassland to continuous arable use, have destructive effects which begin inconspicuously with the uppermost inch or two of the soil profile, but may continue with gathering impetus until the geography of a large tract of country has been altered. The report-reading public has already had examples in plenty described to it, for example, in R. M. Gorrie's *The Use and Misuse of Land* (Oxford Forestry Memoirs, 19, 1935), and to most East African readers the subject will be familiar at first hand in some of its aspects. The main lesson to be learned from a study of such examples of soil destruction caused by excessive removal of herbage, I would summarize as follows:—

One function of the higher plants in the maintenance of a soil is admittedly to provide residues, whose substance after incorporation will have manurial and other ameliorative effects. Good enough substitutes can, however, often be found for these dead residues, and it is a mistake to regard the provision of them as the whole duty of plant life to the soil. Higher plants do not grow merely in or on the soil, any more than micro-organisms do. As participants in a working system

they are *of* the soil, and if their living functions are checked or withheld for too long (as they are in circumstances of excessive grazing or too-prolonged continuance of arable cultivation) the soil reverts towards an inorganic condition in which, being "dead", it is at the mercy of disintegrating forces.

If then the soil is to continue to grow plants for us, in turn we must grow plants for the soil.

There is of course nothing new in this principle, but its recognition in just these terms is, I think, recent. Thus in green manuring, the emphasis has usually been on the value of the *decomposing residues* of the green crop ; any reconstructive activity of its root system during life has been less considered. The same is true of standard doctrine about the rotation of crops: " 'Turnips, barley, clover, wheat'—each takes out what another has left, nitrogen is taken from the air and used, farmyard residues are fermented and returned to the land ; full marks to the chemical processes, the microbes and the livestock, little credit to the growing plants. If any plant competes with your row of beans, he is a weed ; 'that's Roman wormwood—that's pigweed—that's sorrel—that's pipergrass—have at him, chop him up, turn his roots upwards to the sun, don't let him have a fibre in the shade ; if you do, he'll turn himself t'other side up and be as green as a leek in two days' ". (H. D. Thoreau ; *Walden*, 1845.) Yet this is not the whole of the story, as the same American writer, hoeing his beans in New England nearly a century ago, knew well enough. "We are wont to forget that the sun looks on our cultivated fields, and on the prairies and forests without distinction. . . . In his view the earth is all equally cultivated like a garden . . . . Shall I not rejoice also at the abundance of the weeds ?"

There is nowadays an increasing respect for live plants as accessories to soil management, on a valuation other than as harvestable crops or as residue-providers. They are achieving recognition in mechanical functions, as soil binders, water filterers, "ten billion little dams" ; in physical functions as structure formers and as regulators of eco-climate ; in chemical functions as circulators of nutrients and as controllers of oxidation and reduction. The newer outlook is evident (to quote two non-American examples) in the strong advocacy of ley farming by Stapledon's school in England, and in the use of resting periods under Elephant Grass to relieve the pressure of cotton and grain crops on soils in Uganda. In the parts of the West Indies that I visited, it appeared *inter alia* in the interest in forage grasses evident at the Imperial College Farm in Trinidad, especially in Guatemala Grass (*Tripsacum laxum*), Elephant Grass (*Pennisetum purpureum*), Guinea Grass (*Panicum maximum*), and Para Grass (*Panicum barbinode*) ; and also in a very interesting trend away from the use of organic manures in the sugar-cane industry. Farmyard manure (or "penmanure" as it is called in the West Indies) has long been the traditional soil ameliorant amongst sugar planters, and their scientific advisers' attitude towards it until recently is probably fairly represented by the following quotation from a 1924 paper by Professor F. Hardy:—

> "There is no need to extol the many virtues of pen manure, or to reiterate the need of its greater employment in tropical agricultural practice. The main problem that confronts the planter in these days of mechanical tillage is how to manufacture larger quantities of pen manure with diminishing numbers of farm animals".

This, as a general statement, would be warmly agreed to by most tropical agriculturists at the present day and is the basis of the increasing attention being paid almost everywhere to the making of compost. Yet it seems that on sugar-cane fields the "organic matter problem" is now recognised as of subsidiary importance, or even as not arising. The value of pen manure has apparently been that of its contained nutrients and nothing more ; the sugar-cane plant, when grown to high yields with the aid of carefully-adjusted dressings of artificials, appears to maintain the organic matter status of its soils satisfactorily, and, in virtue of its own root-growth, performs all necessary services in soil-structure formation and the like. By the criterion of yield, organic manuring of sugar-cane is not necessary. This at least was the impression I gained in Barbados, in Trinidad and in British Guiana. If the view stands the test of time, it would seem that the cultivation of this particular crop plant, which is a perennial grass, automatically incorporates the advantages and safeguards of ley farming.

In the United States, I saw much soil-management practice based on a constructive use of vegetation, both in the grazing States of the south-west and in the agricultural States of the south-east. In the former, more and more reliance is being placed on recuperation under protected natural or re-seeded pasture. In the latter, the proportion of clean-tilled crops is being reduced wherever possible, so that grass or fodder crops of equivalent habit may occupy the land undisturbed for some period of effective length interposed in the cropping cycle. These measures are of course a part of the general programme of soil conservation, but they are more than merely a means of stopping bodily losses of soil. They are measures consciously aimed at restoring living vegetation to the exercise of a neglected function in soil maintenance.

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TRANSMISSION OF "SWOLLEN SHOOT" DISEASE OF CACAO.

By A. F. Posnette,
(Botanist, Department of Agriculture, Gold Coast.)

Budding from swollen shoots (from Old Tafo) on to healthy stocks was commenced in January, 1938, during a visit to Tafo. The stocks were chupons of three bearing trees in excellent health. On returning from leave in December, 1939, these three trees were found to be severely affected with swellings and the type of die-back associated with "Swollen Shoot". One neighbouring tree showed signs of more recent infection, but no other trees within a radius of over 100 yards appear to be affected.

In October, 1938, six buddings were carried out using swollen shoots from Akwadum. The stocks were native farm seedlings planted three to a hole ; in each group one was budded with a swollen bud and the other two with buds from Asuansi selections as controls. Only two swollen buds "took", one of which apparently killed its stock within a month. The remaining swollen bud is still alive and its stock developed symptoms of "Swollen Shoot" three months after budding. No controls have developed symptoms.

Further budding was done in February, 1939, and grafting by A. E. Pound in June, 1939, resulting in three surviving budlings and one graft, in all of which transmission from scion to stock has occurred.

Noteworthy features of these transmissions have been the high mortality of scion buds, attributed to the moribund condition of affected tissues ; the killing of healthy stocks soon after budding, indicating the virulence of the disease ; and the order of appearance of the symptoms. The first sign of infection appears (about six weeks to two months, after budding) as a leaf chlorosis, chlorophyll of old leaves breaking down between the veins, while new leaves when they appear are chlorotic with green veins.

Young leaves tend to wither immediately after breaking from the bud, leaving a green, leafless shoot with persistent stipules. Later, axillary buds down the stem are stimulated to produce shoots, often in pairs or threes, many of which die back before reaching a length of more than two inches, and show various degrees of swelling at their base.

Typical swelling of the main axis is the last symptom to appear (5–8 months after budding) ; it is usually, but not always, terminal, the apical bud dying. Constriction at the nodes, rather than swelling beyond the normal growth increase of the internodes, is sometimes noticeable on fans.

This evidence of transmissibility, in the absence of any isolated pathogen, suggests that the cause of "Swollen Shoot" is a virus. There is no doubt that the disease is spreading in native farms, and 70 fresh cases have been reported in 1939 from the 60 acres of cacao on Tafo station. Budding has been done in insect-proof cages with a view to experiments in co-operation with the Plant Pathologist and Entomologist on the vector of the disease.

Acknowledgment.

My thanks are due to the Director of Agriculture on the Gold Coast for permission to publish this paper.

NITROGEN AND THE SUGAR CANE.*

Nitrogen not infrequently plays an all-important part in controlling the physiological reactions of plants, and this control becomes of economic importance in the case of many crops. Notably, combined with adequate water to allow of its maximum intake, it will affect the fruiting habit and excess nitrogen will, in such case, be deleterious from the farming point of view. The plant may be thought of as becoming too self-centred and a shock has to be administered to bring home to it the necessity of thinking about the next generation. In the sugar cane the effect is the same but it is not the reproductive cycle that is affected to become of economic importance. It is the maturity of the cane ; the accumulation of sucrose is delayed and such cane is not welcomed in the factory. An abundance of available nitrogen during the growth of the crop may, thus, result in heavy crops, but the sum total result, when the extra cost of handling the bigger weight of cane is taken into account, may be an increased yield of sugar incommensurable with the cost of additional nitrogen or even a diminished yield. It becomes of importance, therefore, to determine the critical figure for the available nitrogen above which lies a supply for luxury consumption resulting in a reduced quality of juice of a magnitude which leads to uneconomic results. The problem is not simple ; the cane plant occupies the ground many months and this critical figure for nitrogen will vary for the different stages of growth. The problem is simple in definition but complex in solution and difficult in application to practice. Nevertheless a solution is desirable, for real efficiency in fertilizer practice is dependent on the answer. Control of fertilizer applications is one of the primary objectives of soil analysis, field experiment and pot cultures. The first of these is inadequate since analysis only gives the available nitrogen at the moment of

* Reprinted from an article in *The International Sugar Journal*, Vol. XLI, No. 492, pp. 452-453.

collection; interaction between it and the soil, the organisms of the soil and direct leaching all play their part in producing this variation. Further, available nitrogen is only one factor affecting the problem, for the plant's reaction to a given quantity will vary according to the environmental conditions to which the plant is subjected.

There is a growing belief that the readiest means of arriving at a solution of the problem will be found in the use of the plant itself as its own analyst. But a plant is a complex structure with the nitrogen unequally distributed through the various tissues, and the question arises, therefore, whether any particular tissue can be accepted as a better indicator of the plant's nitrogen requirements than another. In Mauritius the leaf has been found to offer a satisfactory index for plant food deficiencies in the cane (1) and there has now appeared a recent paper by Q. H. Yuen and F. E. Hance in which not merely the leaf but certain specific portions of certain leaves are found to give the most reliable information (2). The samples are taken with a punch yielding discs of lamina 5 mm. in diam. Each sample consists of 60 discs so cut, two discs being taken from one leaf at a point half way along the length of the blade and midway between the midrib and margin. The sampling zone is composed of the leaves carrying the second to fourth visible ligule counting from the top of the stem. Cane bearing arrows is avoided and reasonable precautions taken that a due proportion of the primary growth is included. For analysis of the samples the rapid chemical method for nitrogen determination was used after check against normal Kjeldahl procedure. Within the range of nitrogen content found, 1 to 3 per cent. dry weight, the accuracy of the method is stated to be within at least 90 per cent. of the regular method of analysis. In practice this means that differences in total nitrogen exceeding 0.40 per cent. may be accepted as significant.

The investigation covers the relationship between nitrogen content of the leaf discs and growth of the cane in pots as well as field results. The pot experiments relate to a basic soil supplied with adequate phosphorous and potash to ensure sufficiency and graded doses of nitrogen, 1, 1.5, 2 and 3 grms. per pot of 4.5 kilos. air-dry soil, in each of which two plants were grown with growth limited to the primary stalk, and continued for 36 weeks. This dose of nitrogen was applied either two weeks after planting, one-half two weeks after planting and the remaining half either as soon as the analyses showed depletion in the soil or when the plants showed definite yellowing of the foliage. The results show a definite correlation between the nitrogen index (percentage N in the dry weight of leaf discs) and growth measured as elongation of the stem. The conclusion is drawn that the nitrogen levels critically related to growth are: 2 per cent., above which is luxury consumption; 1 per cent., a minimum, desirable on maturity; 1.5 per cent., when nitrogen no longer acts as a limiting factor; and 1.3 per cent., below which growth diminishes or, under adverse weather conditions, stops.

The field survey is, naturally, more complicated, not least because growth is not limited to that of the primary stem. It has shown, however, that the same trends of nitrogen in the plant as indicated by the leaf-punch method are also applicable to the field crop. But it shows, further, that the levels of the requirement differ at different stages of growth. Thus, for a 24-month crop the levels are: 2 per cent. at 6 to 8 months, 1.5 per cent. at 12 to 14 months, 1.25 per cent. at 15 to 17 months, and 1.1 per cent. at 24 months. In Hawaii, however, some crops are grown for a shorter period and this may require a modification to ensure a proper maturation of the crop. At the same time, to secure a proper development at the start adequate supplies of nitrogen are required to maintain the critical percentage up to 4 to 6 months. Pending further collection of data, the following levels are suggested: 2 per cent. at 4 to 6 months, 1.5 per cent. at 8 to 10 months, 1.25 per cent. (lower limit) at 10 months, and (upper limit) at 18 months.

It is not possible to discuss these results in detail; interest rather centres in the application of the method to practice. Here, as a starting point, the common practice of the locality as to nitrogen fertilization may be taken. That amount or less will be applied either as a single initial dose or split into a number of doses for successive applications. From three months or earlier and periodically thereafter, leaf-punch samples are taken and the nitrogen percentage determined. The figures so obtained can then be plotted to give a curve indicating the history of the plant throughout its growth. It is then possible readily to compare the curve with the determined critical requirement. Where a deficiency in the nitrogen index is indicated, consideration of all the circumstances, including, perhaps, a determination of the available nitrogen in the soil, will suggest the advisability of the application of a further dressing. As a practical example, the case is given of a crop of H 109 which received at 1.5 months 50 lbs. nitrogen. After 2 months the nitrogen index had dropped to 1.95 from 2.4 per cent., and an additional 50 lbs. nitrogen was applied. At 5 months the index had dropped to 1.74 and again 50 lbs. nitrogen was applied, with a rise of the index to 2.07 at 6.5 months, dropping a fortnight later to 1.95. The suggestion here is that further application was unnecessary, but local practice dictated a further dressing of 75 lbs. which was given with a consequent rise, as indicated by samples taken during the two succeeding months, denoting excess. The actual requirement in this case appears to have been between 150 and 175 lbs. nitrogen. A number of such determinations in different fields suggests that estate practice tends to exceed the optimum requirement.

H. M. LEAKE.

(1) *I.S.J.*, 1939, p. 256.
(2) Hawaiian Planters' Record, 1939, p. 163.

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

Soil Destruction in Malaya.

The damage done to agricultural land by various forms of mining is considered by Sir Lewis L. Fermor in his exhaustive "Report upon the Mining Industry of Malaya" (Kuala Lumpur: Govt. Press, 1939. 6s.). The destruction of land by the stacking of waste rock and gangue is small because the prevalent forms of tin-mining result in floods of water, heavily charged with silt, either as coarse as sand or as fine as mud. This silt, carried by the effluent water, chokes streams and causes flooding to such an extent that silt-retention schemes, necessitating dams or weirs, are obligatory. But much damage has been done in the past, and some is still being done, especially in the mining process of destroying hillside by water under hydraulic pressure. Again the removal of the top layers of soil and their mixing with lower layers, which is unavoidable in the process known as dredging, render the whole surface within a mining concession unfertile by the time the land is returned to agricultural use. Against these objections to mining must be placed the fertilizing value on flooded land of a thin deposit of silt. The writer is insistent that rubber cultivation is equally harmful, in fact more so, in ruining land by encouraging soil erosion and leading to the removal of fertile surface layers. Clean weeding, a fetish of the rubber planter, causes soil removal between the rows of trees, and can be prevented only by the wise use of cover crops. Sir Lewis estimates that rubber cultivation has caused the addition of 33,000,000 tons of silt to the river systems since 1905, while tin-mining has contributed only 16,000,000 tons. The débris from the rubber lands is both coarse and fine, and does more harm than the fine silt from the mines, some of which is carried to sea, and some of which fertilizes the land.—(*Nature*, Vol. 144, No. 3656, p.901, 1939.)

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Molasses as Manure for Sugar Cane (in Australia). *By E. W. Kerr.*

In a review of various local circumstances affecting cane culture in an irrigated region, it is stated that even when the proportion of clay in the soil is small it is generally in a highly dispersed and stickly state, and its properties bring with them special cultivation problems.

Following irrigation, considerable difficulty is experienced in restoring the soil to a state of good tilth, and if cultivation be delayed unduly the soil breaks up into intractable clods. The farmers of the area (Lower Burdekin district) are at present devoting considerable attention to the amelioration of this soil condition.

One line of approach which has given encouraging results is the application of moderate dressings of molasses, either to ratoon crops or to fallow land. In fact the apparently permanent benefits from the treatment are so widely appreciated, that the demand for reasonably priced molasses now exceeds the supply.

These experiences suggest that any practice designed to increase the organic matter content of the soil might effect similar results. Trash conservation is therefore urged, though the slow rate at which this material decomposes during the normal summer months, due to moisture deficiencies is an objection.—(*Int. Sugar Jr.*, Vol. XLI, No. 492, 1939.)

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Losses of Potash from Sugar-cane Soils. *By P. L. Gow.*

In ratoon sugar-cane pots, potassium applied as either neutral salt or carbonate was not leached to any serious extent. When potassium was applied to cane pots at the same time as sulphate of ammonia, the leaching of potassium was not significantly greater than that which occurred when the application of potassium was delayed until after nitrification of the sulphate of ammonia had taken place. Somewhat lower losses of potassium were indicated in uncropped pots which did not receive potassium until after nitrification had occurred. No important conservation of potassium was gained by the use of potassium carbonate in cane pots, but lower losses of potassium were indicated by the use of potassium carbonate in uncropped pots. Retention of applied potassium by an acid soil in the absence of vegetation was poor, but in the presence of cane was very good, indicating highly efficient uptake of potassium by ratoon cane. Seriously increased loss of potassium by leaching as a result of long-continued use of acid-forming fertilizers appears unlikely to occur in soils cropped to sugar-cane.—(*Chemical Abstracts*, Vol. XXXIV, No. 3, Col. 842, 1940.)

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Isolation and Properties of Crystalline Papain.

A method is described for the isolation of a crystalline protein of high enzymic activity from papaya latex. The enzyme is activated by cyanide, sulphydryl compounds, and the like, and will digest hemoglobin with a velocity comparable to the pancreatic proteinases. It also clots milk and hydrolyses hippurylamide. It is quite stable in dilute alkali (up to pH 10.5) but is unstable in dilute acid (below pH 4.5). The isolated protein is but slightly soluble in dilute salt solutions, particularly at low temperatures, and behaves like a prolamin to the extent that it is soluble in 70 per cent. alcohol. It is isoelectric at about pH 9.0 and has a molecular weight of about 27,000 measured by osmotic pressure. The protein contains 15.5 per cent. nitrogen, 1.2 per cent. total sulphur, 1.0 per cent. cystine sulphur, and 0.0 per cent. phosphorus.—(*Journ. Biol. Chem.*, 1939, Vol. CXXX, No. 2, p. 669.)